A STRONG ELECTROWEAK SECTOR AT FUTURE COLLIDERS

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Abstract

A brief overview of the production at future colliders of two new triplets of spin one resonances from a strong electroweak breaking is presented.

Fits to the electroweak precision data assuming the Standard Model (SM) suggest a light Higgs; however the data do not necessarily exclude possible extensions with a large Higgs mass provided that its effect is compensated by the effect of some new high order operator or of some new particle [1]. A recent critical review of this option can be found in [2]. These new operators or the presence of new particles can give distinctive signatures at new accelerators like LHC and future linear colliders. For instance operators of order p^4 appearing in the non linear breaking effective lagrangian can be detected by studying WW scattering at future colliders with the sensitivity shown in [3]; a review of some possible signatures concerning new resonances can be found in [4]. Among the models with new vector particles I will present here a brief overview of the phenomenology of the degenerate BESS model.

The degenerate BESS model (D-BESS) [5] is a realization of dynamical electroweak symmetry breaking which predicts the existence of two new triplets of gauge bosons almost degenerate in mass ($L^\pm$, L_3), ($R^\pm$, R_3). The extra parameters are a new gauge coupling constant g'' and a mass parameter M, related to the scale of the underlying symmetry breaking sector. In the charged sector the $R^\pm$ fields are unmixed and $M_{R^\pm} = M$, while $M_{L^\pm} \simeq M(1+x^2)$ where $x = g/g''$ with g the usual $SU(2)_W$ gauge coupling constant. The L_3, R_3 masses are given by $M_{L_3} \simeq M\left(1+x^2\right)$, $\quad M_{R_3} \simeq$

Table 1: Sensitivity to L_3 and R_3 production at the LHC and CLIC for L =100(500) fb^{-1} with M =1,2(3) TeV at LHC and L =1000 fb^{-1} at CLIC.

g/g''	M (GeV)	Γ_{L_3} (GeV)	Γ_{R_3} (GeV)	$\frac{S}{\sqrt{S+B}}$ LHC (e,μ)	$S/\sqrt{S+B}$ CLIC (had)	ΔM CLIC
0.1	1000	0.7	0.1	17.3		
0.2	1000	2.8	0.4	44.7		
0.1	2000	1.4	0.2	3.7		
0.2	2000	5.6	0.8	8.8		
0.1	3000	2.0	0.3	(3.4)	62	$23.20 \pm .06$
0.2	3000	8.2	1.2	(6.6)	152	$83.50 \pm .02$

$M\left(1+x^2\tan^2\theta\right)$ where $\tan\theta = s_\theta/c_\theta = g'/g$ and g' is the usual $U(1)_Y$ gauge coupling constant. These resonances are narrow and almost degenerate in mass; this model respects the existing stringent bounds from electroweak precision data since the S,T,U (or $\epsilon_1,\epsilon_2,\epsilon_3$) parameters vanish at the leading order in the large M expansion due to an additional custodial symmetry. Therefore the precision electroweak data only set loose bounds on the parameter space of the model.

Future hadron colliders may be able to discover these new resonances by their production through quark annihilation and decay in the lepton channel: $q\bar{q}' \to L^\pm, W^\pm \to (e\nu_e)\mu\nu_\mu$ and $q\bar{q} \to L_3, R_3, Z, \gamma \to (e^+e^-)\mu^+\mu^-$. The main backgrounds, left to these channels after the lepton isolation cuts, are the Drell-Yan processes with SM gauge bosons exchange in the electron and muon channel. A study has been performed using Pythia and CMSJET, which performs a simulation of the energy smearing of CMS detector [6]. Results are given in table 1 for the sum of the electron and muon channels for $L = 100$ fb^{-1}. For the case M =3 TeV the results are given for an integrated luminosity of 500 fb^{-1}. The discovery limit at LHC with $L = 100$ fb^{-1} is $M \sim 2$ TeV with $g/g'' = 0.1$. Beyond discovery, the possibility to disentangle the double peak structure depends strongly on g/g'' and smoothly on the mass [6]. A lower energy LC can also probe this multi-TeV region through the virtual effects in the cross-sections for $e^+e^- \to L_3, R_3, Z, \gamma \to f\bar{f}$.

Assuming a resonant signal to be seen at the LHC or at a lower LC, the multi-TeV collider can measure its width, mass and investigate the existence of an almost degenerate structure [7]. The ability in identifying the model distinctive features has been studied using the CLIC production cross section and the flavour dependent forward-backward asymmetries, for different values of g/g''. The CLIC luminosity spectrum has been obtained with a dedicated beam simulation program for the nominal parameters at $\sqrt{s}$ = 3 TeV. The resulting distributions for M = 3 TeV and g/g'' = 0.15 are shown in fig. 1 for the case of the CLIC.02 beam parameters (a luminosity, L=0.40$\times10^{35}$ cm^{-2} s^{-1} and a number of photons radiated per $e^{\pm}$ in the bunch, N_{γ}=1.2).

This study has demonstrated that with 1000 fb^{-1} of data, CLIC will be able to resolve the two narrow resonances for values of the coupling ratio $g/g'' > 0.08$, corresponding to a mass splitting ΔM = 13 GeV for M = 3 TeV, and to determine ΔM with a statistical accuracy better than 100 MeV (see table 1).

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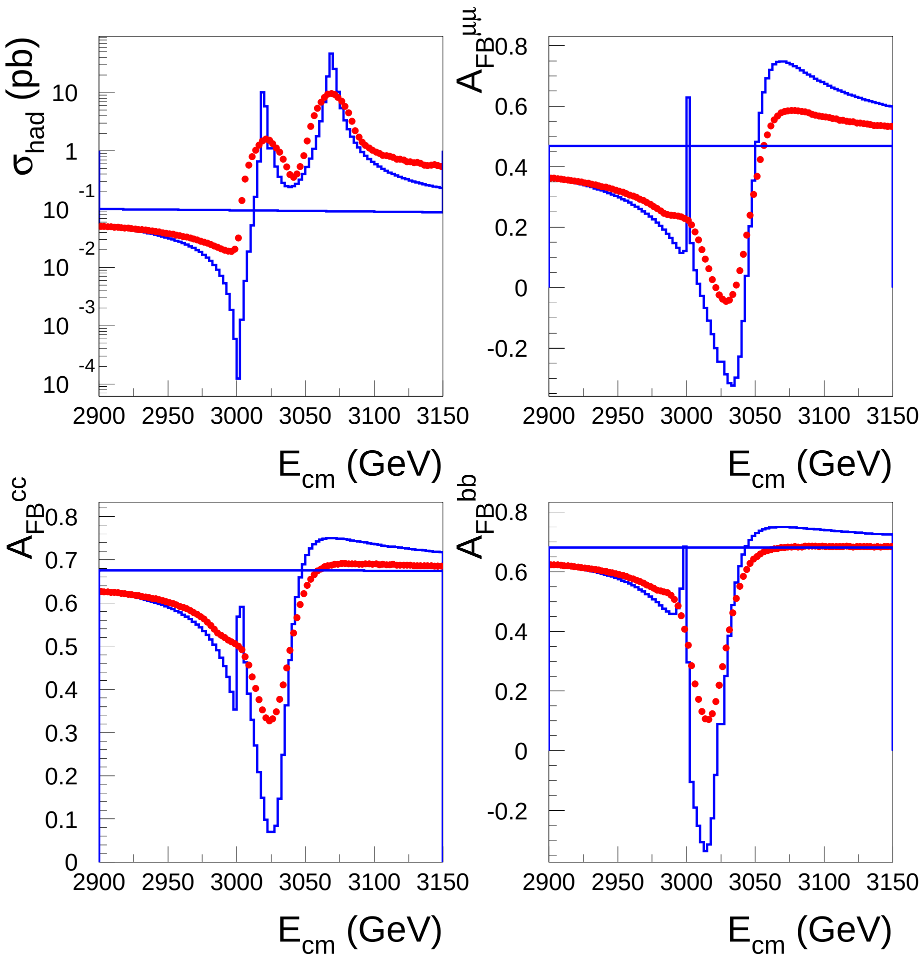

Figure 1: The hadronic cross section (upper left) and $\mu^+\mu^-$ (upper right), $b\bar{b}$ (lower left) and $c\bar{c}$ (lower right) forward-backward asymmetries at energies around 3 TeV. The continous lines represent the predictions for the D-BESS model with $M =$ 3 TeV and $g/g'' = 0.15$, the flat lines the SM expectation and the dots the observable D-BESS signal after accounting for the CLIC.02 luminosity spectrum